TAP 416-1: The effect of loading a generator

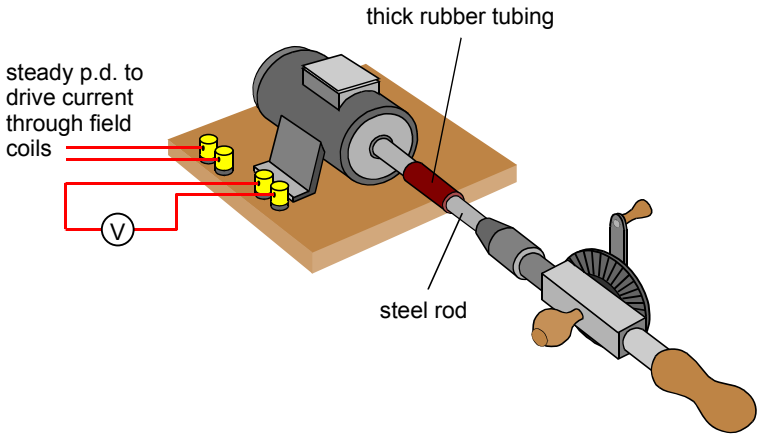
Here you use a large ac motor acting as a generator to show the forces that act on the rotor and how they change when the generator provides a current to a load such as a bulb. You can't get something for nothing!

You will need:

- ✓ three filament lamps, 12 V, 24 W
- ✓ three spst switches
- ✓ demonstration multimeter, used as a voltmeter
- ✓ large ac motor / generator with separate connections to field coils and armature
- ✓ hand drill
- ✓ power supply, 0–12 V
- ✓ leads, 4 mm
- ✓ digital multimeter
- ✓ variable-speed power drill

Hand-powered dynamo

A current is induced in the coil of a dynamo as it turns. This current experiences a force in the field that is in the opposite direction to the motion that induced the current. Just because it is being used as a generator, a current-carrying coil of wire cannot know that it is not meant to feel the motor effect! The more current the dynamo supplies the harder it gets to turn it.



1. The motor can be turned at a speed fast enough to light a bulb using a hand drill. Try it. The axle of the motor should be clamped in the chuck of the drill. Set the field current at about 0.5 A and turn the drill at a steady speed. Start with a voltmeter connected to the rotor coil to measure the induced emf.

2. How does the induced emf change as the drill is rotated faster?

3. Replace the voltmeter with a 12 V lamp. Switch more and more lamps in, whilst turning. The drill will be noticeably harder to turn.

4. The lamp has a much lower resistance than the voltmeter, which means that there will be a current in the rotor.

5. Why does this make it harder to turn the drill?

Things to remember

1. The induced emf is proportional to the speed of rotation of the rotor coil. As the rotor moves in the field, the emf increases as the rotor turns faster. The rate of cutting of flux has increased.

2. When there is a current in the rotor a force acts which tries to slow down the speed of rotation of the rotor. This is an example of the dynamo and motor effects occurring together. A force acts on the rotor but in a direction that opposes the original motion. This is an example of Lenz's law – the induced emf opposes the change that causes it.

	**Be safe** When driving motors and generators at high speeds (i.e. not manually) the pulleys and belt drive must be guarded to prevent trapping fingers, entanglement of clothing and to catch the belt should it fail

Practical advice

The point here is that students begin to understand how an induced current can give rise to a force acting against the motion which induces the current. A dynamo cannot help being a motor. Students should also see that the induced emf increases with the rate of flux cutting as described by Faraday's law, but the effect of the iron in the rotor will probably mean that direct proportionality will not be observed. A variable-speed drill allied with a frequency meter can produce excellent results however; a plot of induced emf / rotational frequency is suitable.

Remember that the main aim is to feel the retarding force and to attempt to explain it. Consistency with Faraday's law should be considered as a bonus.

If your school does not already own one of these motor/generators, they can be difficult to obtain.

Alternative approaches

A car generator (few modern cars use an ac generator, almost all cars have alternators with built in diodes) driven by a motor will show the same effect. The generator uses a rotating electromagnet and the voltmeter (or bulb) is connected to the stator windings. Use a dc power supply to provide a current for the rotor; start with about 0.5 A.

Social and human context

The discussion of generators can naturally lead to the electricity distribution industry, the historical development of electricity distribution and its effects on society (for example, electrical household appliances).

Be safe

When driving motors and generators at high speeds (i.e. not manually) the pulleys and belt drive must be guarded to prevent trapping fingers, entanglement of clothing and to catch the belt should it fail

External reference

This activity is taken from Advancing Physics chapter 15, 310P